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Isomura

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(54) **UNINTERRUPTIBLE POWER SYSTEM, METHOD OF CONTROLLING POWER SUPPLY, AND RECORDING MEDIUM HAVING POWER SUPPLY CONTROL PROGRAM STORED THEREIN**

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(52) **U.S. Cl.**
CPC . ***H02J 9/04*** (2013.01); ***H02J 9/062*** (2013.01); *Y10T 307/62* (2015.04)

(58) **Field of Classification Search**
USPC 361/65
See application file for complete search history.

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Primary Examiner — Ronald W Leja

(57) **ABSTRACT**

An uninterruptible power system includes a plurality of uninterruptible power units connected in parallel to input power. One uninterruptible power unit includes a rechargeable battery, a charging circuit that supplies a charging current to the rechargeable battery, and an output circuit that outputs power supplied from the rechargeable battery as output power. The uninterruptible power system includes a path switching unit in which switching of a path for power received among the charging circuit, the rechargeable battery and the output circuit in the plurality of uninterruptible power units is performed, and a control unit that controls the path switching unit so that switching of the path is performed according to states of the uninterruptible power units.

6 Claims, 6 Drawing Sheets

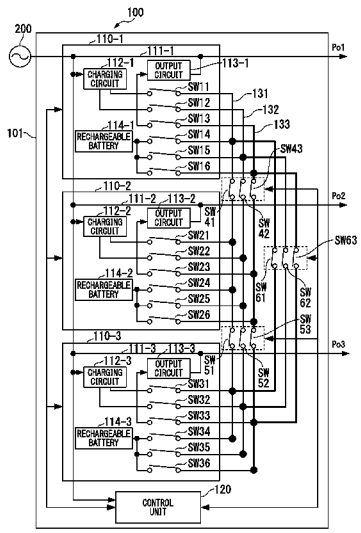

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FIG. 1

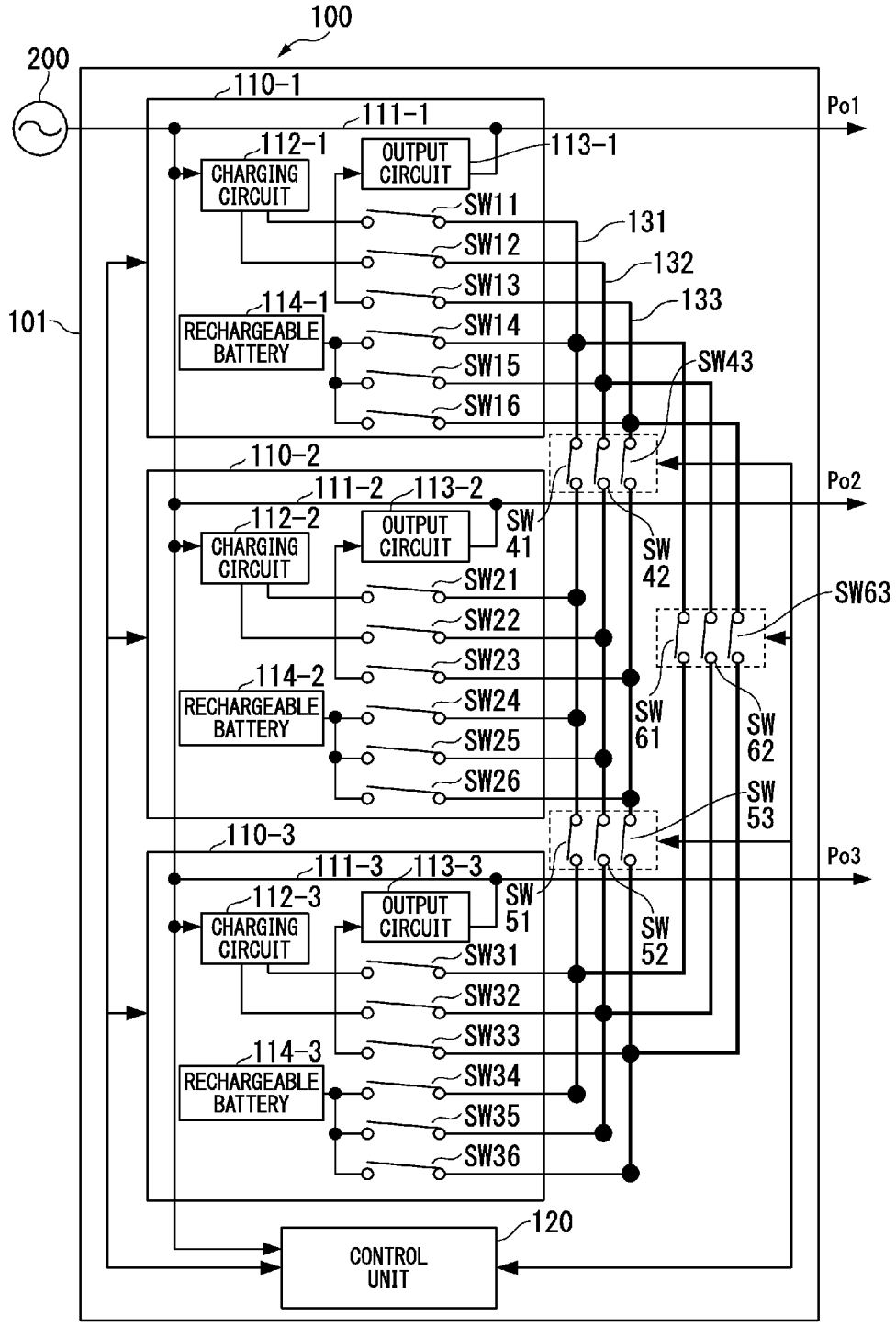

100
200
110-1
111-1
Po1
112-1
CHARGING CIRCUIT
OUTPUT CIRCUIT
113-1
SW11
131
SW12
132
SW13
133
114-1
RECHARGEABLE BATTERY
101
SW14
SW15
SW43
SW16
110-2
111-2
113-2
Po2
112-2
CHARGING CIRCUIT
OUTPUT CIRCUIT
SW 41
SW 42
SW63
SW21
SW22
SW23
114-2
RECHARGEABLE BATTERY
SW24
SW 61
SW 62
SW25
SW26
SW 53
110-3
111-3
113-3
Po3
112-3
CHARGING CIRCUIT
OUTPUT CIRCUIT
SW 51
SW 52
SW31
SW32
SW33
114-3
RECHARGEABLE BATTERY
SW34
SW35
SW36
120
CONTROL UNIT

FIG. 2

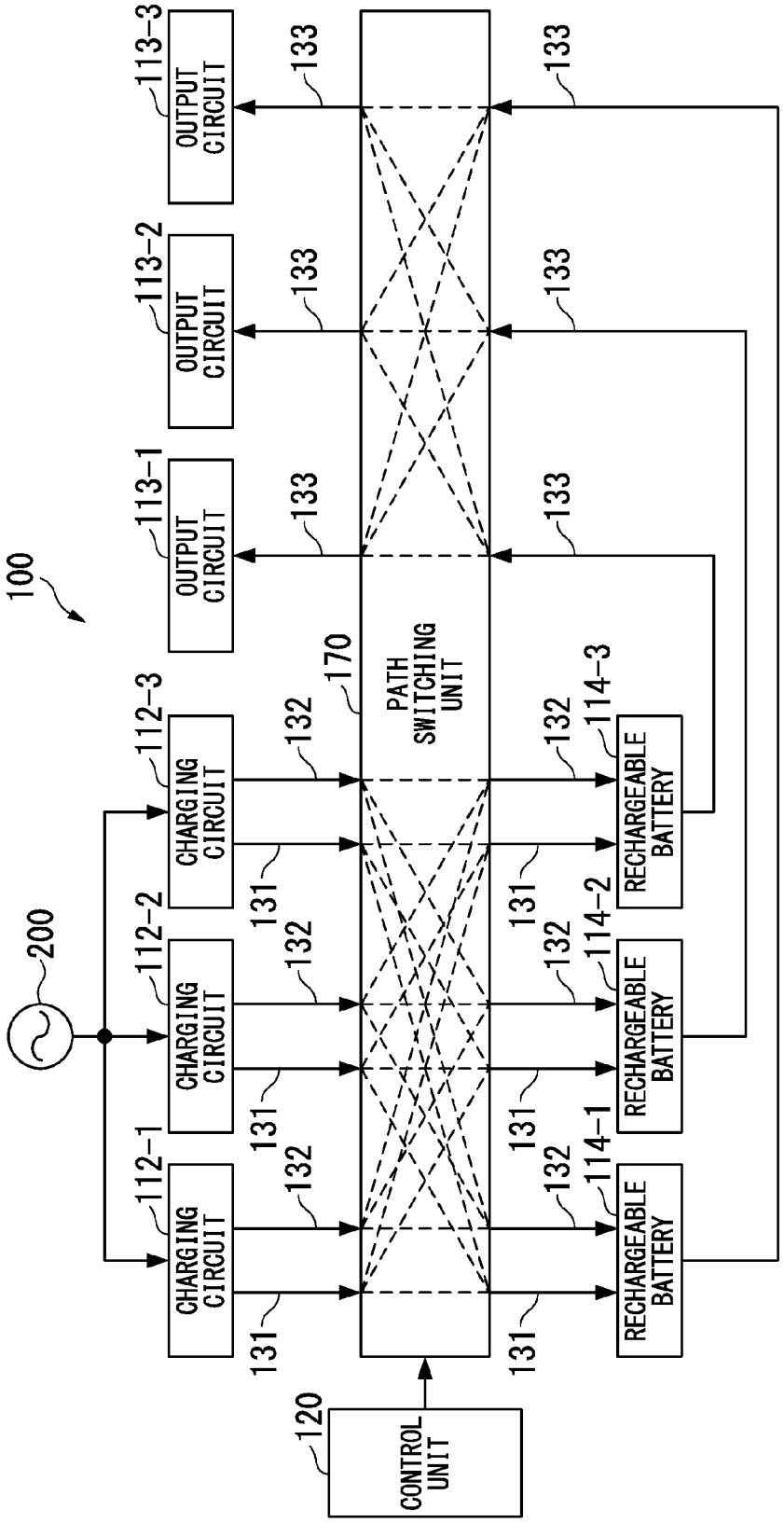

100
200
120
CONTROL UNIT
PATH SWITCHING UNIT
170
CHARGING CIRCUIT
112-1
112-2
112-3
OUTPUT CIRCUIT
113-1
113-2
113-3
RECHARGEABLE BATTERY
114-1
114-2
114-3
131
132
133

FIG. 3

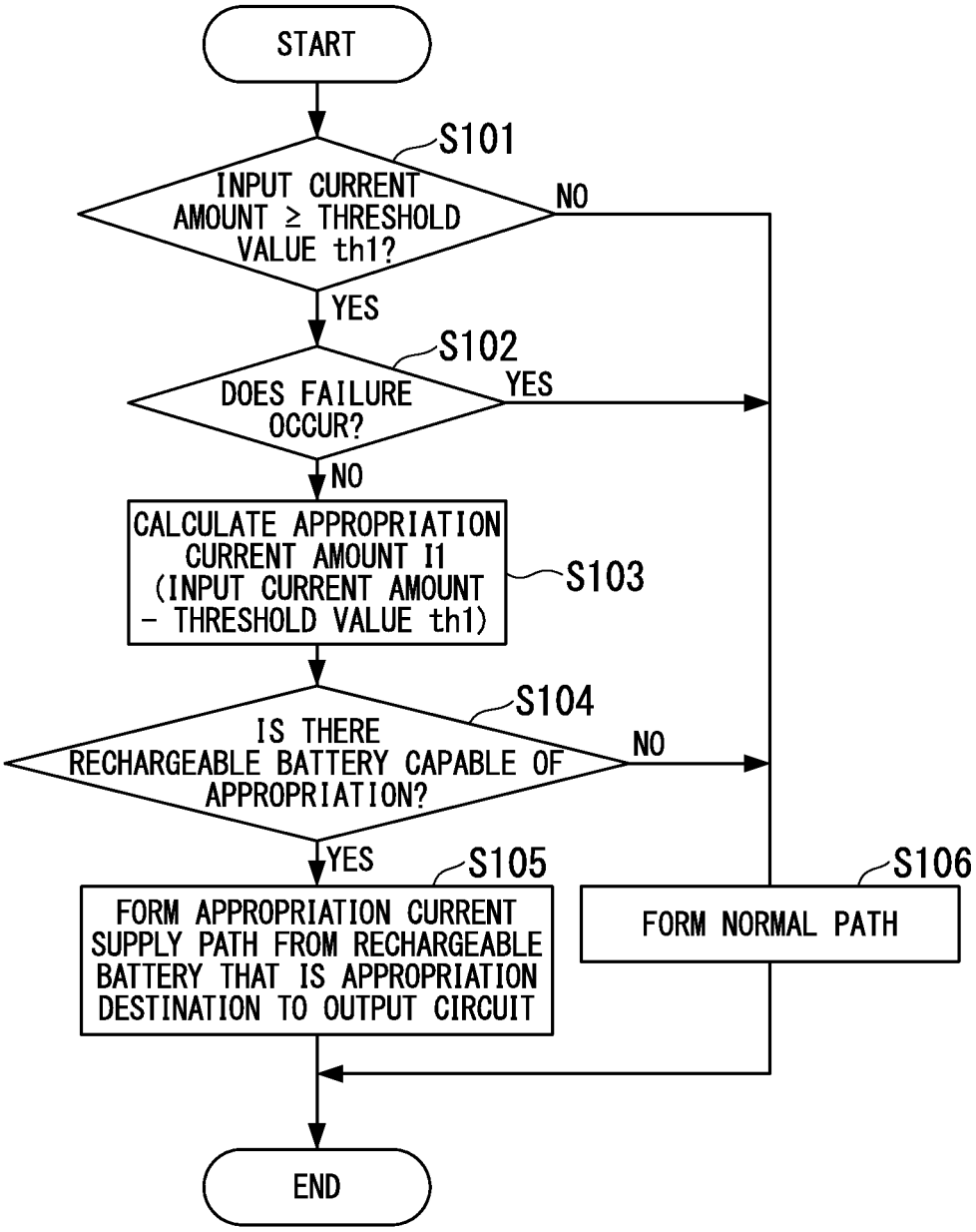

START
S101
INPUT CURRENT AMOUNT ≥ THRESHOLD VALUE th1?
NO
YES
S102
DOES FAILURE OCCUR?
YES
NO
CALCULATE APPROPRIATION CURRENT AMOUNT I1 (INPUT CURRENT AMOUNT - THRESHOLD VALUE th1)
S103
S104
IS THERE RECHARGEABLE BATTERY CAPABLE OF APPROPRIATION?
NO
YES
S105
FORM APPROPRIATION CURRENT SUPPLY PATH FROM RECHARGEABLE BATTERY THAT IS APPROPRIATION DESTINATION TO OUTPUT CIRCUIT
S106
FORM NORMAL PATH
END

FIG. 4

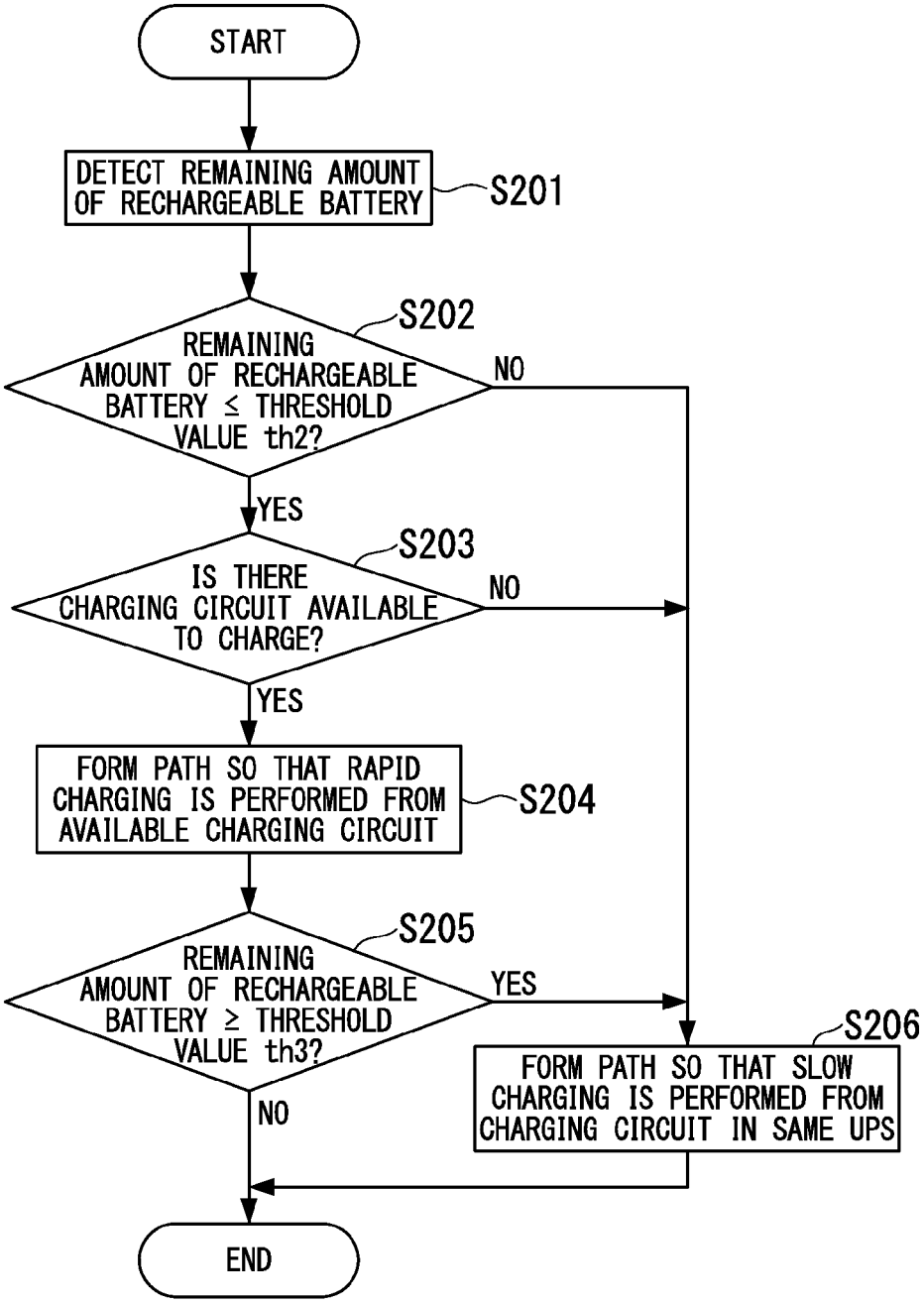

START
DETECT REMAINING AMOUNT OF RECHARGEABLE BATTERY
S201
S202
REMAINING AMOUNT OF RECHARGEABLE BATTERY ≤ THRESHOLD VALUE th2?
NO
YES
S203
IS THERE CHARGING CIRCUIT AVAILABLE TO CHARGE?
NO
YES
FORM PATH SO THAT RAPID CHARGING IS PERFORMED FROM AVAILABLE CHARGING CIRCUIT
S204
S205
REMAINING AMOUNT OF RECHARGEABLE BATTERY ≥ THRESHOLD VALUE th3?
YES
NO
S206
FORM PATH SO THAT SLOW CHARGING IS PERFORMED FROM CHARGING CIRCUIT IN SAME UPS
END

FIG. 5

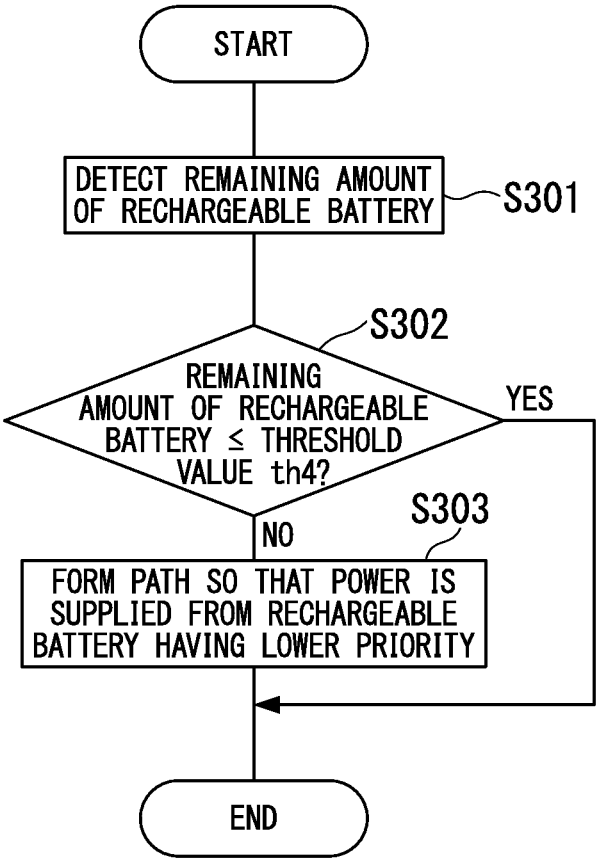
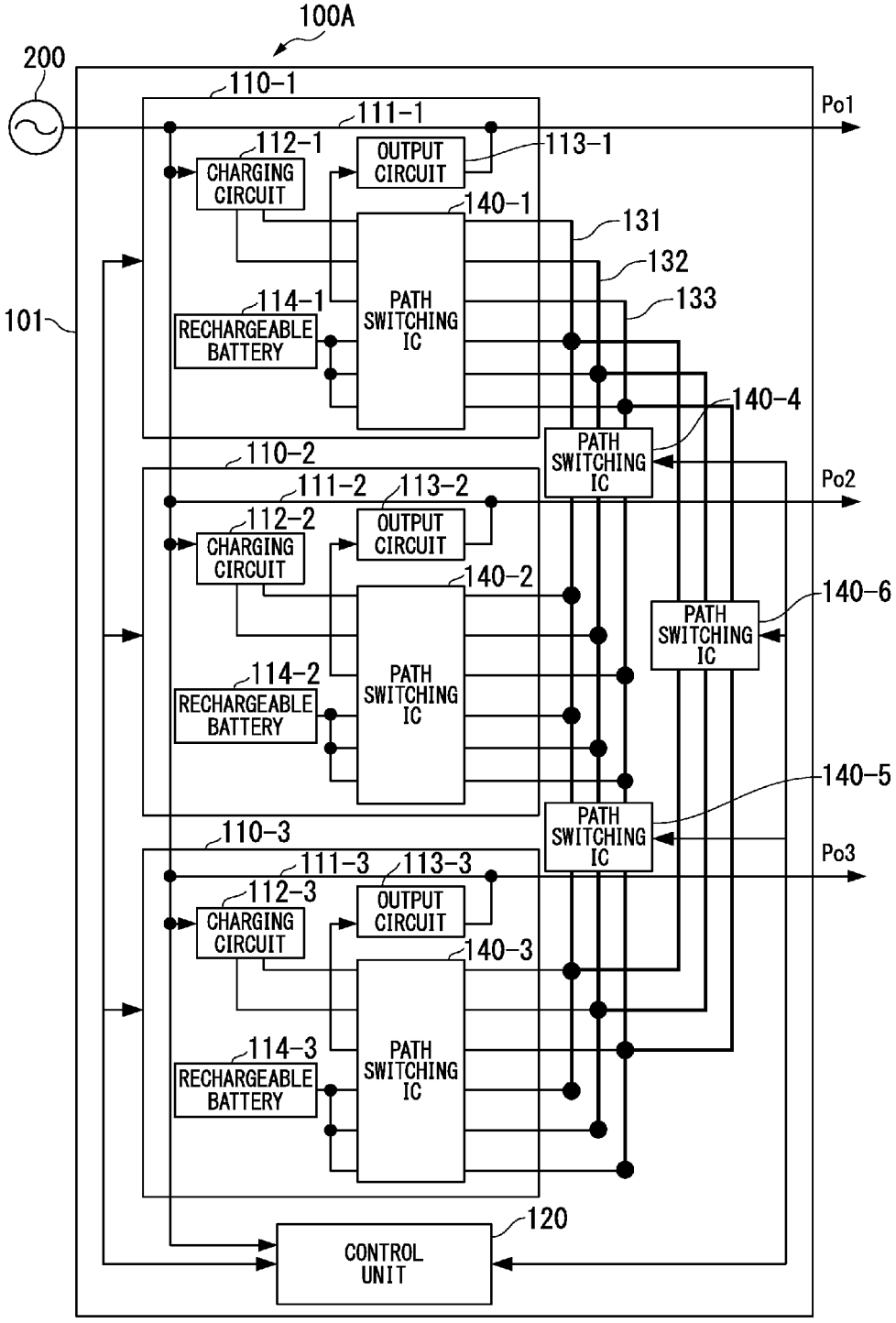

START
DETECT REMAINING AMOUNT OF RECHARGEABLE BATTERY
S301
S302
REMAINING AMOUNT OF RECHARGEABLE BATTERY ≤ THRESHOLD VALUE th4?
YES
NO
S303
FORM PATH SO THAT POWER IS SUPPLIED FROM RECHARGEABLE BATTERY HAVING LOWER PRIORITY
END

FIG. 6


100A
200
110-1
111-1
Po1
112-1
CHARGING CIRCUIT
OUTPUT CIRCUIT
113-1
140-1
131
132
133
101
114-1
RECHARGEABLE BATTERY
PATH SWITCHING IC
140-4
PATH SWITCHING IC
110-2
111-2
113-2
Po2
112-2
CHARGING CIRCUIT
OUTPUT CIRCUIT
140-2
140-6
PATH SWITCHING IC
114-2
RECHARGEABLE BATTERY
PATH SWITCHING IC
140-5
PATH SWITCHING IC
110-3
111-3
113-3
Po3
112-3
CHARGING CIRCUIT
OUTPUT CIRCUIT
140-3
114-3
RECHARGEABLE BATTERY
PATH SWITCHING IC
120
CONTROL UNIT

UNINTERRUPTIBLE POWER SYSTEM, METHOD OF CONTROLLING POWER SUPPLY, AND RECORDING MEDIUM HAVING POWER SUPPLY CONTROL PROGRAM STORED THEREIN

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an uninterruptible power system, and a method of controlling a power supply and a program in the uninterruptible power system.

2. Description of Related Art

An uninterruptible power system that supplies power accumulated in a rechargeable battery to a load in place of commercial AC power when an abnormality such as interruption of the commercial AC power occurs is known.

As such an uninterruptible power system, a control signal from an operation management device connected in parallel to a plurality of UPSs (Uninterruptible Power Supplies) to control the plurality of UPSs to interwork with one another is disclosed in Japanese Unexamined Patent Application, first Publication (JP-A), No. H10-098839.

However, in the configuration disclosed in JP-A No. H10-098839, each of the plurality of UPSs has an individually complete configuration except that the control signal is common. Accordingly, for example, a rechargeable battery included in one UPS cannot be used for outputting power or charging another UPS unit.

SUMMARY OF THE INVENTION

An object of the invention is to provide an uninterruptible power system, a method of controlling a power supply, and a program capable of resolving the above problem.

An uninterruptible power system as an aspect of the present invention includes: a plurality of uninterruptible power units each including a rechargeable battery, a charging circuit configured to charge the rechargeable battery using input power, and an output circuit configured to output power stored in the rechargeable battery in place of the input power when supply of the input power stops, the uninterruptible power units being connected in parallel to the input power; a path switching unit configured to perform switching of a path for power received among the charging circuit, the rechargeable battery and the output circuit in the plurality of uninterruptible power units; and a control unit configured to control the path switching unit so that switching of the path is performed according to states of the uninterruptible power units.

A method of controlling a power supply in an uninterruptible power system as an aspect of the present invention includes preparing a plurality of uninterruptible power units each including a rechargeable battery, a charging circuit configured to charge the rechargeable battery using input power, and an output circuit configured to output power stored in the rechargeable battery in place of the input power when supply of the input power stops, the uninterruptible power units being connected in parallel to the input power; and controlling a path switching unit so that switching of a path for power received among the charging circuit, the rechargeable battery and the output circuit in the plurality of uninterruptible power units is performed according to the states of the uninterruptible power units.

Further, a program as an aspect of the present invention causes a computer to execute a control step of controlling, according to states of a plurality of uninterruptible power units each including a rechargeable battery, a charging circuit configured to charge the rechargeable battery using input power, and an output circuit configured to output power stored in the rechargeable battery in place of the input power when supply of the input power stops, a path switching unit so that switching of a path for power received among the charging circuit, the rechargeable battery and the output circuit in the plurality of uninterruptible power units is performed, the uninterruptible power units being connected in parallel to the input power.

According to the present invention, in the uninterruptible power system including a plurality of uninterruptible power units, the rechargeable battery, the charging circuit, or the like included in one uninterruptible power unit can be used for another uninterruptible power unit, thereby improving the flexibility of power reception.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram illustrating an uninterruptible power system according to an embodiment of the present invention;

FIG. **2** is a block diagram illustrating a power reception path among a charging circuit, an output circuit and a rechargeable battery in the uninterruptible power system according to an embodiment of the present invention;

FIG. **3** is a flowchart illustrating a process procedure performed by a control unit with respect to an overload in an embodiment of the present invention;

FIG. **4** is a flowchart illustrating a process procedure in which the control unit performs rapid charging of a rechargeable battery in an embodiment of the present invention;

FIG. **5** is a flowchart illustrating a process procedure performed by the control unit to control power supply in an embodiment of the present invention; and

FIG. **6** is a block diagram illustrating an uninterruptible power system according to a variant of the embodiment of the present invention.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

Hereinafter, an uninterruptible power system according to an embodiment of the present invention will be described with reference to the drawings.

The uninterruptible power system according to the present embodiment includes, at least, a plurality of uninterruptible power units connected in parallel to input power, a path switching unit that performs switching of a path for power received among a charging circuit, a rechargeable battery and an output circuit in the plurality of uninterruptible power units, and a control unit that controls the path switching unit so that switching of the path is performed according to the state of the uninterruptible power unit.

FIG. **1** illustrates an example of a configuration of an uninterruptible power system **100** in the present embodiment. The uninterruptible power system **100** illustrated in FIG. **1** includes three UPS (Uninterruptible Power Supply) units **110-1**, **110-2** and **110-3** and a control unit **120** in a housing **101**.

The UPS unit **110-1** is an uninterruptible power unit using a continuous commercial power supply scheme. The continuous commercial power supply scheme is a scheme of outputting commercial AC power (input power) via a surge protection circuit and a noise filter in a normal situation and outputting power from a rechargeable battery, for example, when failure such as interruption of the commercial AC power occurs.

The UPS unit **110-2** is an uninterruptible power unit using a line interactive scheme. The line interactive scheme refers to a scheme for outputting commercial AC power via a surge protection circuit and a noise filter in a normal situation, and determining that failure has occurred when a noise waveform that cannot be removed by the noise filter is detected and outputting power from a rechargeable battery.

The UPS unit **110-3** is an uninterruptible power unit using an inverter scheme. The inverter scheme is a scheme for outputting commercial AC power from a converter via an inverter in a normal situation and outputting power of the rechargeable battery via the inverter when failure occurs.

The commercial AC power **200** is input to the UPS units **110-1** to **110-3** in parallel. In other words, the UPS units **110-1** to **110-3** are included to be parallel to the commercial AC power **200**.

The UPS unit **110-1** includes a through path **111-1** that receives the commercial AC power **200** and directly outputs the commercial AC power **200** as output power Pol. Further, the output power Po**1** is supplied as power to a predetermined load device. In addition, the UPS unit **110-1** includes a charging circuit **112-1**, an output circuit **113-1**, a rechargeable battery **114-1** and path switching switches SW**11** to SW**16**.

The charging circuit **112-1** receives the commercial AC power **200** and outputs a charging current. The charging circuit **112-1** outputs two charging currents such as a charging current for rapid charging and a charging current for slow charging. For example, the charging current for rapid charging has a larger current than the charging current for slow charging. The charging current for rapid charging is supplied to a rapid charging line **131** via the path switching switch SW**11**, and the charging current for slow charging is supplied to a slow charging line **132** via the path switching switch SW**12**.

When DC power is supplied from a discharging line **133** via the path switching switch SW**13**, the output circuit **113-1** converts the DC power into AC power and outputs the AC power as the output power Po1.

The rechargeable battery **114-1** performs charging by means of a supplied charging current to accumulate power, and discharges the accumulated power.

Specifically, when the charging current for rapid charging is supplied from the rapid charging line **131** via the path switching switch SW**14**, the rechargeable battery **114-1** performs rapid charging by means of the charging current for rapid charging. Further, when the charging current for slow charging is supplied from the slow charging line **132** via the path switching switch SW **15**, the rechargeable battery **114-1** performs rapid charging by means of the charging current for slow charging. Further, when the rechargeable battery **114-1** is connected with the discharging line **133** via the path switching switch SW **16**, the rechargeable battery **114-1** discharges the accumulated power and outputs the power to the discharging line **133**.

The UPS unit **110-2** includes a through path **111-2** due to a configuration similar to the UPS unit **110-1**. Further, the UPS unit **110-2** includes a charging circuit **112-2**, an output circuit **113-2**, a rechargeable battery **114-2**, and path switching switches SW**21** to SW**26**.

Further, the UPS unit **110-3** includes a through path **111-3** due to a configuration similar to the UPS unit **110-1** and the UPS unit **110-2**. Further, the UPS unit **110-3** includes a charging circuit **112-3**, an output circuit **113-3**, a rechargeable battery **114-3**, and path switching switches SW**31** to SW**36**.

Further, a scheme corresponding to each of the UPS units **110-1**, **110-2** and **110-3** is not limited to the above-described scheme. Further, each of the UPS units **110-1**, **110-2** and **110-3** does not necessarily adopt a different scheme and at least two of them may correspond to the same scheme.

Further, as understood from the above description, the rapid charging line **131** is a line shared by the UPS units **110-1**, **110-2** and **110-3** for reception of the charging current for rapid charging. The slow charging line **132** is a line shared by the UPS units **110-1**, **110-2** and **110-3** for reception of the charging current for slow charging. The discharging line **133** is a line shared by the UPS units **110-1**, **110-2** and **110-3** for reception of discharged power.

Further, in the rapid charging line **131**, the slow charging line **132** and the discharging line **133**, path switching switches SW**41**, SW**42** and SW**43** are connected between the UPS unit **110-1** and the UPS unit **110-2**. Similarly, in the rapid charging line **131**, the slow charging line **132** and the discharging line **133**, path switching switches SW**51**, SW**52** and SW**53** are connected between the UPS unit **110-2** and the UPS unit **110-3**. Further, path switching switches SW**61**, SW**62** and SW**63** are connected between the UPS unit **110-1** and the UPS unit **110-3**.

The control unit **120** performs control so that switching of a path for power received among the charging circuits **112-1**, **112-2** and **112-3**, the output circuits **113-1**, **113-2** and **113-3**, and the rechargeable batteries **114-1**, **114-2**, and **114-3** according to predetermined states in the UPS units **110-1**, **110-2** and **110-3** is performed. Accordingly, the control unit **120** individually controls on/off of the path switching switches SW**11** to SW**16**, the path switching switches SW**21** to SW**26**, the path switching switches SW**31** to SW**36**, the path switching switches SW**41** to SW**43**, the path switching switches SW**51** to SW**53**, and the path switching switch SW**61** to SW**63**.

Further, hereinafter, the UPS units **110-1**, **110-2** and **110-3** are described as a UPS unit **110** when mentioned without particular discrimination. Similarly, the through paths **111-1**, **111-2** and **111-3** are described as a through path **111** when mentioned without particular discrimination. The charging circuits **112-1**, **112-2** and **111-3** are described as a charging circuit **112** when mentioned without particular discrimination. Further, the output circuits **113-1**, **113-2** and **113-3** are described as an output circuit **113** when mentioned without particular discrimination. Further, the rechargeable batteries **114-1**, **114-2** and **114-3** are described as a rechargeable battery **114** when mentioned without particular discrimination.

FIG. **2** schematically illustrates a power reception path formed among the charging circuit **112**, the output circuit **113**, and the rechargeable battery **114** realized by the configuration illustrated in FIG. **1**. Further, in FIG. **2**, the same reference numerals are assigned to the same units as those in FIG. **1**.

A path switching unit **170** illustrated in FIG. **2** is a unit in which switching of the path for power among the charging circuits **112-1**, **112-2** and **112-3**, the output circuits **113-1**, **113-2** and **113-3** and the rechargeable batteries **114-1**, **114-2**, and **114-3** is performed under control of the control unit **120**. The path switching unit **170** corresponding to FIG. **1** may be regarded as including the path switching switches SW**11** to SW**16**, the path switching switches SW**21** to SW**26**, the path switching switches SW**31** to SW**36**, the path switching switches SW**41** to SW**43**, the path switching switches SW**51** to SW**53**, and the path switching switches SW**61** to SW**63**.

As illustrated in FIG. **2**, the path switching unit **170** may connect the charging circuits **112-1**, **112-2** and **112-3** with the rechargeable batteries **114-1**, **114-2**, and **114-3** via the rapid charging line **131** according to an arbitrary combination.

Further, the path switching unit **170** may connect the charging circuits **112-1**, **112-2** and **112-3** with the rechargeable

batteries **114-1**, **114-2**, and **114-3** via the slow charging line **132** according to an arbitrary combination.

Further, the path switching unit **170** may connect the rechargeable batteries **114-1**, **114-2**, and **114-3** with the output circuits **113-1**, **113-2** and **113-3** via the discharging line **133** according to an arbitrary combination.

For example, particularly, the UPS unit **110-1** outputs the input commercial AC power **200** via the through path **111-1** as the output power Po1 in a normal situation in which failure does not occur. Further, the UPS unit **110-1** performs slow charging of the rechargeable battery **114-1** using the charging circuit **112-1** and causes power stored at this time not to be output from the output circuit **113-1** so that the stored power is not discharged.

Similarly, the UPS unit **110-2** outputs the input commercial AC power **200** as output power Po2 via the through path **111-2**. Further, the UPS unit **110-2** performs slow charging of the rechargeable battery **114-2** using the charging circuit **112-2** and causes stored power not to be output from the output circuit **113-2**.

Similarly, the UPS unit **110-3** outputs the input commercial AC power **200** as output power Po3 via the through path **111-3**. Further, the UPS unit **110-3** performs slow charging of the rechargeable battery **114-3** using the charging circuit **112-3** and causes stored power to not be output from the output circuit **113-3**.

In other words, in the normal situation, the UPS unit **110** individually operates independently to output the commercial AC power **200** as output power via the through path **111** therein and cause slow charging of the rechargeable battery **114** to be performed using the charging circuit **112**.

For this reason, the control unit **120** turns off the path switching switches SW**41**, SW**42**, SW**43**, SW**51**, SW**52**, SW**53**, SW**61**, SW**62**, and SW**63**. Accordingly, the rapid charging line **131**, the slow charging line **132** and the discharging line **133** are disconnected between the UPS units **110-1**, **110-2**, and **110-3**. In addition, the control unit **120** turns on the path switching switches SW**12** and SW**15** in the UPS unit **110-1** and turns off the path switching switches SW**11**, SW**13**, SW**14** and SW**16**. Further, the control unit **120** turns on the path switching switches SW**22** and SW**25** in the UPS unit **110-2** and turns off the path switching switches SW**21**, SW**23**, SW**24**, and SW**26**.

Further, the control unit **120** turns on the path switching switches SW**32** and SW**35** in the UPS unit **110-3** and turns off the path switching switches SW**31**, SW**33**, SW**34**, and SW**36**.

On the other hand, the UPS unit **110-1** is assumed to be in an overload state in which an input current amount is larger than or equal to a previously set specified value, for example, as the load increases. Further, the input current amount may be detected, for example, as follows. That is, a current detection circuit (not shown) that detects an amount of current flowing through the through path **111** is included. Also, the control unit **120** may monitor the current amount detected by the current detection circuit.

In this case, for example, when power for appropriating the current exceeding the specified value has been accumulated in any of the rechargeable batteries **114-1**, **114-2**, and **114-3**, the control unit **120** performs path switching in the path switching unit **170** so that the rechargeable battery **114** is connected with the output circuit **113-1** of the UPS unit **110-1** via the discharging line **133**.

Specifically, rechargeable batteries capable of appropriating the current among the rechargeable batteries **114-1**, **114-2**, and **114-3** are assumed to be the rechargeable battery **114-1** and the rechargeable battery **114-2**. In this case, the control unit **120** turns on the path switching switch SW**43** in FIG. **1** so that the discharging line **133** of the UPS unit **110-1** and the UPS unit **110-2** is shared. The control unit **120** also turns on the path switching switches SW**13** and SW**16** in the UPS unit **110-1**. The control unit **120** also turns on SW**26** in the UPS unit **110-2**.

Accordingly, respective power accumulated in the rechargeable battery **114-1** and the rechargeable battery **114-2** is supplied from the discharging line **133** to the output circuit **113-1**. The output circuit **113-1** converts the input power into AC power, adjusts a current amount so that the current exceeding the default value is appropriated, and outputs the AC power as the output power Pol.

Thus, in the present embodiment, when any of the UPS units **110** reaches an overload state, the input current from the rechargeable battery **114** in the UPS unit **110** may be appropriated.

The flowchart of FIG. **3** illustrates an example of a process procedure executed by the control unit **120** in a state in which any of the UPS units **110** is overloaded as described above. Further, the process illustrated in FIG. **3** is a process in which one UPS unit **110** is a target. The control unit **120** iteratively executes the process illustrated in FIG. **3** at a predetermined timing in parallel for the UPS units **110-1**, **110-2** and **110-3**.

First, the control unit **120** detects an input current in the UPS unit **110** that is a current processing target and determines whether an amount of the input current is larger than or equal to a threshold value th**1** corresponding to the above-described specified value (step S**101**).

Here, if the input current amount is determined to be smaller than the threshold value th**1** (step S**101**-NO), the UPS unit **110** is not in an overload state but in a normal state. The control unit **120** controls on/off states of the path switching switches, which form the path switching unit **170**, so that an operation of the UPS unit **110** corresponding to the normal state is performed as described above (step S**106**).

On the other hand, if it is determined that the UPS unit **110** is in an overload state in which the input current amount is larger than or equal to the threshold value th**1** (step S**101**-YES), the control unit **120** also determines whether failure has occurred (step S**102**). Here, one concrete example of the failure that is a determination target may include a state in which the supply of the commercial AC power **200** stops, for example, due to power failure.

If it is determined that the failure has occurred (step S**102**-YES), each UPS unit **110** other than the target should supply output power from the rechargeable battery **114**. In this case, the control unit **120** controls on/off states of the path switching switches in the path switching unit **170** so that a path for power corresponding to the normal state is formed (step S**106**).

On the other hand, if it is determined that failure does not occur (step S**102**-NO), the control unit **120** calculates an appropriation current amount I**1** (step S**103**). The appropriation current amount I**1** is a current amount exceeding a default value in the input current amount. The control unit **120** calculates the appropriation current amount I**1**, for example, by subtracting a threshold value th**1** (i.e., the default value) from the absolute value of the detected input current amount.

Next, the control unit **120** determines whether there is a rechargeable battery **114** capable of appropriating the appropriation current amount I**1** calculated as described above among the rechargeable batteries **114-1**, **114-2** and **114-3** (step S**104**). For this reason, the control unit **120** compares an accumulated power amount in each of the rechargeable batteries **114-1**, **114-2** and **114-3** with a predetermined threshold value. If the accumulated power amount is equal to or greater than the threshold value, the rechargeable battery **114** has

accumulated a power amount for appropriating the appropriation current amount I1. If the accumulated power amount is smaller than the threshold value, the rechargeable battery **114** has not accumulated the power amount for appropriating the appropriation current amount I1.

If it is determined that there is no rechargeable battery **114** capable of appropriating the appropriation current amount I1 (step S**104**-NO), the control unit **120** performs control so that the path corresponding to the normal state is formed (step S **106**). On the other hand, if it is determined that there is the rechargeable battery **114** capable of appropriating the appropriation current amount I1 (step S**104**-YES), the control unit **120** executes the following process.

That is, the control unit **120** controls on/off states of the path switching switches in the path switching unit **170** so that a path via which the accumulated power of the rechargeable battery **114** capable of appropriation is output to the output circuit **113** in the UPS unit **110** that is a current processing target via the discharging line **133** is formed (step S**105**). Accordingly, in the UPS unit **110** that is a processing target, the appropriation current amount I1 from the output circuit **113** is combined with the input current from the through path **111** so that appropriation of a current according to an overload is performed.

Further, in the present embodiment, charging of the rechargeable battery **114** may be performed between the UPS units **110** as follows. That is, the remaining amount of the rechargeable battery **114** in one UPS unit **110** is assumed to have been smaller than or equal to a certain amount in a state in which the commercial AC power **200** is supplied. In this case, rapid charging of the rechargeable battery **114** whose remaining amount is smaller than or equal to the certain amount may be performed by the charging circuit **112** available to charge the rechargeable battery **114** whose remaining amount is smaller than or equal to the certain amount among the charging circuits **112** included in the respective UPS units **110**.

As one concrete example, the remaining amount of the rechargeable battery **114-1** in the UPS unit **110-1** is assumed to be smaller than or equal to the certain amount. In this case, the charging circuit **112-1** and the charging circuit **112-3** among the charging circuits **112-1**, **112-2** and **112-3** are assumed to be available to charge the rechargeable battery **114-1**. Since the charging circuit **112-2** performs, for example, rapid charging of the rechargeable battery **114-2** in the same UPS unit **110-2**, the charging circuit **112-2** is assumed not to be available to charge the rechargeable battery **114-1**.

In this case, the control unit **120** controls the path switching unit **170** to form a path for charging of the rechargeable battery **114-1** of the UPS unit **110-1** using each of the charging circuit **112-1** and the charging circuit **112-3** via the rapid charging line **131**.

Specifically, the control unit **120** turns on the path switching switch SW**61** in FIG. **1** to cause the rapid charging line **131** to be shared between the UPS unit **110-1** and the UPS unit **110-3**. In addition, the control unit **120** turns on the path switching switches SW**11** and SW**14** in the UPS unit **110-1**. The control unit **120** also turns on SW**31** in the UPS unit **110-3**. Accordingly, rapid charging of the rechargeable battery **114-1** of the UPS unit **110-1** is performed by the charging circuit **112-1** of the UPS unit **110-1** and the charging circuit **112-3** of the UPS unit **110-3** via the rapid charging line **131**.

The flowchart of FIG. **4** illustrates an example of a process procedure executed by the control unit **120** to perform rapid charging of the rechargeable battery **114** in any of the UPS units **110** as described above. Further, the process illustrated in FIG. **4** is a process in which the rechargeable battery **114** in one UPS unit **110** is a target. The control unit **120** iteratively executes the process illustrated in FIG. **4** at a predetermined timing in parallel for the rechargeable batteries **114-1**, **114-2**, and **114-3** of the respective UPS units **110**.

First, the control unit **120** detects a remaining amount of the rechargeable battery **114**, which is a current processing target (step S**201**). The control unit **120** then determines whether the detected remaining amount is smaller than or equal to a previously set threshold value th**2** (step S**202**).

Here, if it is determined that the remaining amount is smaller than or equal to the threshold value th**2** (step S**202**-YES), the control unit **120** determines whether there is a charging circuit **112** available to charge the rechargeable battery **114** that is the processing target (step S**203**).

Here, if it is determined that there is the available charging circuit **112** (step S**203**-YES), the control unit **120** executes the following process. That is, the control unit **120** forms a path so that charging of the rechargeable battery **114**, which is the processing target, is performed by the charging circuit **112** determined to be available in step S**202** via the rapid charging line **131** (step S**204**).

Then, the control unit **120** determines whether the remaining amount of the rechargeable battery **114**, which is the processing target, is equal to or greater than a threshold value th**3** (th**3**>th**2**) (step S**205**). If it is determined that the remaining amount is smaller than the threshold value th**3** (step S**205**-NO), the rechargeable battery **114** does not yet reach a previously determined charging capacity, which corresponds to completion of rapid charging. In this case, the control unit **120** first ends the process illustrated in FIG. **4** and then restarts the process from step S**201** at a predetermined timing.

Also, if it is determined that the remaining amount is equal to or greater than the threshold value th**3** (step S**205**-YES), the control unit **120** executes the following process. That is, the control unit **120** controls on/off states of the path switching switches in the path switching unit **170** so that a path via which slow charging of the rechargeable battery **114** of the processing target is performed by the charging circuit **112** in the same UPS unit **110** is formed (step S**206**). Further, an operation in which slow charging of the rechargeable battery **114** is performed by the charging circuit **112** in the same UPS unit **110** as described above corresponds to the operation in the normal state. Further, even when it is determined that the remaining amount exceeds the threshold value th**2** (step S**202**-NO) and when it is determined that there is no charging circuit available to charge the rechargeable battery **114**, which is the processing target (step S**203**-NO), the control unit **120** executes the process of step S**206**.

Further, when backup of a device is performed as the supply of the commercial AC power **200** stops, for example, due to power failure, the uninterruptible power system **100** of the present embodiment operates as follows as the remaining amount of the rechargeable battery **114** is smaller than or equal to a certain amount.

In the uninterruptible power system **100** of the present embodiment, a different priority is set for each UPS unit **110**. Here, it is assumed that the priority of the UPS unit **110-1** is highest, the priority of the UPS unit **110-2** is next highest, and the priority of the UPS unit **110-3** is lowest. The priorities correspond to, for example, priorities of backup for load devices connected to the UPS units **110-1**, **110-2** and **110-3**. This implies that the backup of the load device connected to the UPS unit **110-1** has the highest priority.

If the supply of the commercial AC power **200** stops, for example, due to power failure, the control unit **120** first performs control so that each of the UPS units **110-1**, **110-2** and

110-3 independently performs backup of the load device. In other words, the control unit **120** performs control so that a path via which the power accumulated in the rechargeable battery **114-1** is supplied to only the output circuit **113-1** via the discharging line **133** is formed in the UPS unit **110-1**. Further, the control unit **120** performs control so that a path via which the power accumulated in the rechargeable battery **114-2** is supplied to only the output circuit **113-2** via the discharging line **133** is formed in the UPS unit **110-2**. Further, the control unit **120** performs control so that a path via which the power accumulated in the rechargeable battery **114-3** is supplied to only the output circuit **113-3** via the discharging line **133** is formed in the UPS unit **110-3**.

In this case, as states of the path switching switches in FIG. **1**, any of the path switching switches SW**43**, SW**53** and SW**63** is turned off to disconnect the discharging line **133** between the UPS units **110-1**, **110-2**, and **110-3**. In addition, the path switching switches SW**13** and SW**16** in the UPS unit **110-1** are turned on to supply the power from the rechargeable battery **114-1** to the output circuit **113-1** via the discharging line **133**. Similarly, the path switching switches SW**23** and SW**26** in the UPS unit **110-2** are turned on to supply the power from the rechargeable battery **114-2** to the output circuit **113-2** via the discharging line **133**. Further, the path switching switches SW**33** and SW**36** in the UPS unit **110-3** are turned on to supply the power from the rechargeable battery **114-3** to the output circuit **113-3** via the discharging line **133**.

As the backup is performed as described above, the remaining amount of each rechargeable battery **114** is gradually reduced over time. Also, in the present embodiment, when the remaining amount of the rechargeable battery **114** in one UPS unit **110** is smaller than or equal to the certain amount, the power of the rechargeable battery **114** in the UPS unit **110** having a lower priority than such a UPS unit **110** is also used for backup of the UPS unit **110** having a higher priority.

As one concrete example, the remaining amount of the rechargeable battery **114** in the UPS unit **110-1** is assumed to be smaller than or equal to the certain amount in backup. In this case, the UPS unit **110-1** has the highest priority. The control unit **120** controls the path so that power discharged from the rechargeable battery **114-2** in the UPS unit **110-2** and the rechargeable battery **114-3** in the UPS unit **110-3** that have lower priorities is also supplied to the output circuit **113-1** of the UPS unit **110-1** via the discharging line **133**.

In this case, the control unit **120** turns on the path switching switches SW**43** and SW**53** to cause the discharging line **133** to be shared by the UPS units **110-1**, **110-2** and **110-3**. Further, the control unit **120** maintains the on-state of the path switching switches SW**13** and SW**16** in the UPS unit **110-1**, similar to the state before the remaining amount is smaller than or equal to a certain amount. In addition, the control unit **120** turns on the path switching switch SW**26** in the UPS unit **110-2** and the path switching switch SW**36** in the UPS unit **110-3**. Accordingly, the powers from the rechargeable batteries **114-2** and **114-3** as well as the rechargeable battery **114-1** are supplied to the output circuit **113-1** of the UPS unit **110-1**. Accordingly, the device to which the output power Po**1** of the UPS unit **110-1** having the highest priority of backup is supplied can be operated for as long a period of time as possible.

FIG. **5** illustrates an example of a process procedure executed by the control unit **120** in order to control power supply from the rechargeable battery **114** to the output circuit **113** according to the priority of the UPS unit **110** at the time of backup as described above. Further, the process illustrated in FIG. **5** is a process in which one UPS unit **110** is a target. The control unit **120** iteratively executes the process illustrated in FIG. **5** at a predetermined timing in parallel for the UPS units **110-1**, **110-2** and **110-3**.

First, the control unit **120** detects the remaining amount of the rechargeable battery **114** in the UPS unit **110** that is a processing target (step S**301**). The control unit **120** then determines whether the detected remaining amount is smaller than or equal to a threshold value th**4** (step S**302**).

If it is determined that the remaining amount exceeds the threshold value th**4** (step S**302**-NO), there is still room in the remaining amount of the rechargeable battery **114** in the UPS unit **110**, which is a processing target. In this case, the control unit **120** first ends the process illustrated in FIG. **5** and then restarts the process from step S**301** at a predetermined timing.

On the other hand, if it is determined that the remaining amount is smaller than or equal to the threshold value th**4** (step S**302**-YES), there is no room in the remaining amount of the rechargeable battery **114** in the UPS unit **110**, which is a processing target. In this case, the control unit **120** controls the path switching switches in the path switching unit **170** so that a path via which power is supplied from the rechargeable battery **114** in the UPS unit **110** having a lower priority than the UPS unit **110** which is the processing target to the output circuit **113** of the UPS unit **110** which is the processing target is formed (step S**303**).

Further, in the above description, as the remaining amount of the rechargeable battery **114** in one UPS unit **110** is smaller than or equal to the certain amount, switching of the path is performed so that the power is supplied from the rechargeable batteries **114** in all the UPS units **110** having lower priorities. Other method of assigning the rechargeable battery **114** according to a priority in backup may be considered. As one example, the following method of assigning the rechargeable battery **114** may be considered. That is, when the remaining amount of the rechargeable battery **114** in one UPS unit **110** is smaller than or equal to the certain amount, first, the power is supplied from the rechargeable battery **114** in the UPS unit **110** having the lowest priority among the UPS units **110** having lower priorities. Also, as the remaining amount of the rechargeable battery **114** of the UPS unit **110** having the lowest priority disappears, the power is supplied from the rechargeable battery **114** of the UPS unit **110** having the next lowest priority. This is iteratively performed.

Further, in the present embodiment, the uninterruptible power system **100** includes the plurality of UPS units **110** using different schemes in parallel in the housing **101**, making it possible to supply power using an appropriate scheme according to usage of a load device through one uninterruptible power system **100**.

Further, in the present embodiment, for example, even when the rechargeable battery **114** in any of the UPS units **110** is pulled out in a state in which the uninterruptible power system **100** is in operation, for example, the power is supplied from the rechargeable battery **114** of the other UPS unit **110**. In other words, a unit such as the rechargeable battery **114** in the uninterruptible power system **100** can be hot-swapped.

Further, in the present embodiment, even when a fault such as failure of the charging circuit **112** or the rechargeable battery **114** has occurred, for example, charging may be performed by the charging circuit **112** of the other UPS unit **110** or power may be supplied from the rechargeable battery **114** in the other UPS unit **110**. In other words, it is possible to continuously operate the uninterruptible power system **100** by removing a faulty circuit.

FIG. **6** illustrates an example of a configuration of an uninterruptible power system **100**A according to a variant. Further, in FIG. **6**, the same reference numerals are assigned to the same units as those in FIG. **1** and a description of the same

units will be omitted. The uninterruptible power system **100**A illustrated in FIG. **6** includes a path switching IC (Integrated Circuit) **140-1** in place of the path switching switches SW**11**, SW**12**, SW**13**, SW**14**, SW**15** and SW**16**. The path switching IC **140-1** performs switching of a path, which corresponds to individual turning-on/off of the path switching switches SW**11**, SW**12**, SW**13**, SW**14**, SW**15** and SW**16** in FIG. **1** under control of a control unit **120**.

Further, the uninterruptible power system **100**A includes a path switching IC **140-2** in place of the path switching switches SW**21**, SW**22**, SW**23**, SW**24**, SW**25** and SW**26**. The path switching IC **140-2** performs switching of a path, which corresponds to individual turning-on/off of the path switching switches SW**21**, SW**22**, SW**23**, SW**24**, SW**25** and SW**26** in FIG. **1** under control of the control unit **120**.

Further, the uninterruptible power system **100**A includes a path switching IC **140-3** in place of the path switching switches SW**31**, SW**32**, SW**33**, SW**34**, SW**35** and SW**36**. The path switching IC **140-3** performs switching of a path, which corresponds to individual turning-on/off of SW**31**, SW**32**, SW**33**, SW**34**, SW**35** and SW**36** in FIG. **1** under control of the control unit **120**.

Further, the uninterruptible power system **100**A includes a path switching IC **140-4** in place of the path switching switches SW**41**, SW**42**, and SW**43**. The path switching IC **140-4** performs switching of a path, which corresponds to individual turning-on/off of the path switching switches SW**41**, SW**42** and SW**43** in FIG. **1** under control of the control unit **120**.

Further, the uninterruptible power system **100**A includes a path switching IC **140-5** in place of the path switching switches SW**51**, SW**52** and SW**53**. The path switching IC **140-5** performs switching of a path, which corresponds to individual turning-on/off of path switching switches SW**51**, SW**52** and SW**53** in FIG. **1** under control of the control unit **120**.

Further, the uninterruptible power system **100**A includes a path switching IC **140-6** in place of the path switching switches SW**61**, SW**62**, and SW**63**. The path switching IC **140-6** performs switching of a path, which corresponds to individual turning-on/off of the path switching switches SW**61**, SW**62** and SW**63** in FIG. **1** under control of the control unit **120**.

In the uninterruptible power system **100**A having such a configuration, the paths among the charging circuit **112**, the output circuit **113** and the rechargeable battery **114** in the respective UPS units **110** can be switched as described with reference to FIG. **2**. In addition, in the uninterruptible power system **100**A, the path switching switches are omitted. Accordingly, for example, it is possible to avoid an increase in the number of path switching switches according to an increase in the number of UPS units **110**.

Further, a program for realizing a function as the control unit **120** in the present embodiment may be recorded in a computer-readable recording medium, and the program recorded in the recording medium may be read and executed by a computer system to perform an execution process. Further, the "computer system" noted herein may include an operating system (OS) and hardware such as peripheral devices. Further, the "computer system" includes a WWW system including a homepage provision environment (or a display environment). Further, the "computer-readable recording medium" includes a storage device, including a portable medium such as a flexible disk, a magneto-optical disc, a ROM or a CD-ROM, or a hard disk embedded in the computer system. Further, the "computer-readable recording medium" includes a medium for holding a program for a certain period of time, such as a volatile memory (a DRAM) inside a computer system configured of a server and a client when the program is transmitted via a network such as the Internet or a communication line such as a telephone line.

Further, the program may be transmitted from a computer system storing the program in a storage device to other computer systems via a transmission medium or by a transmission wave in the transmission medium. Here, the "transmission medium" transmitting the program is a medium having a function of transmitting information, such as a network (communication network) such as the Internet or a communication line such as a telephone line. Further, the program may be a program for realizing a portion of the above-described function. Further, the program may be a program capable of realizing the above-described function through a combination with a program already recorded in the computer system, i.e., may be a differential file (differential program).

Some or all of the exemplary embodiments are described as the following notes, but are not limited to the following:

(Supplementary note 1) An uninterruptible power system including:

a plurality of uninterruptible power units each including a rechargeable battery, a charging circuit configured to charge the rechargeable battery using input power, and an output circuit configured to output power stored in the rechargeable battery in place of the input power when supply of the input power stops, the uninterruptible power units being connected in parallel to the input power;

a path switching unit configured to perform switching of a path for power received among the charging circuit, the rechargeable battery and the output circuit in the plurality of uninterruptible power units; and

a control unit configured to control the path switching unit so that switching of the path is performed according to states of the uninterruptible power units.

(Supplementary note 2) The uninterruptible power system according to Supplementary note 1, wherein the path switching unit performs switching of the path in such a manner that any of the rechargeable batteries is charged by any of the charging circuits or switching of the path in such a manner that power is supplied from any of the rechargeable batteries to any of the output circuits.

(Supplementary note 3) The uninterruptible power system according to Supplementary note 1 or 2, wherein the control unit controls the path switching unit for the uninterruptible power unit that is a power appropriation target whose input current is larger than or equal to a threshold value, to switch to a path via which power from the rechargeable battery in the other uninterruptible power unit is supplied to the output circuit in the uninterruptible power unit that is the power appropriation target.

(Supplementary note 4) The uninterruptible power system according to any one of Supplementary notes 1 to 3, wherein the control unit controls the path switching unit to switch to a path via which charging of the rechargeable battery that is a charging target whose remaining amount is smaller than or equal to a certain amount is performed by the charging circuit in the uninterruptible power unit including the rechargeable battery that is the charging target, as well as by the charging circuits of the uninterruptible power units other than the uninterruptible power unit including the rechargeable battery that is the charging target.

(Supplementary note 5) The uninterruptible power system according to any one of Supplementary notes 1 to 4, wherein:

different priorities are set in the plurality of uninterruptible power units, and

the control unit controls the path switching unit to switch to a path via which power from the rechargeable battery of the uninterruptible power unit having a lower priority is supplied to the output circuit of one uninterruptible power unit when the power of the rechargeable battery is output from the uninterruptible power unit.

(Supplementary note 6) A method of controlling a power supply in an uninterruptible power system, the method including:

preparing a plurality of uninterruptible power units each including a rechargeable battery, a charging circuit configured to charge the rechargeable battery using input power, and an output circuit configured to output power stored in the rechargeable battery in place of the input power when supply of the input power stops, the uninterruptible power units being connected in parallel to the input power; and

controlling a path switching unit so that switching of a path for power received among the charging circuit, the rechargeable battery and the output circuit in the plurality of uninterruptible power units is performed according to states of the uninterruptible power units.

(Supplementary note 7) A program for causing a computer to execute a control step of controlling, according to states of a plurality of uninterruptible power units each including a rechargeable battery, a charging circuit configured to charge the rechargeable battery using input power, and an output circuit configured to output power stored in the rechargeable battery in place of the input power when supply of the input power stops, a path switching unit so that switching of a path for power received among the charging circuit, the rechargeable battery and the output circuit in the plurality of uninterruptible power units is performed, the uninterruptible power units being connected in parallel to the input power.

Incorporation by Reference

This application claims the benefits of Japanese Patent Application No. 2011-277705, filed Dec. 19, 2011, the disclosure of which is hereby incorporated herein by reference in its entirety.

What is claimed is:

1. An uninterruptible power system comprising:

a plurality of uninterruptible power units each including a rechargeable battery, a charging circuit configured to charge the rechargeable battery using input power, and an output circuit configured to output power stored in the rechargeable battery in place of the input power when supply of the input power stops, the uninterruptible power units being connected in parallel to the input power;

a path switching unit configured to perform switching of a path for power received among the charging circuit, the rechargeable battery and the output circuit in the plurality of uninterruptible power units; and

a control unit configured to control the path switching unit so that switching of the path is performed according to states of the uninterruptible power units,

wherein the control unit controls the path switching unit to switch to a path via which rapid charging of the rechargeable battery that is a charging target, whose remaining amount is smaller than or equal to a first threshold amount, is performed by the charging circuit in the uninterruptible power unit including the rechargeable battery that is the charging target, as well as by the charging circuits of the uninterruptible power units other than the uninterruptible power unit including the rechargeable battery that is the charging target, and

wherein the control unit controls the path switching unit to switch to a path via which slow charging of the rechargeable battery that is a charging target, whose remaining amount is greater than or equal to a second threshold amount, is performed by the charging circuit in the uninterruptible power unit including the rechargeable battery that is the charging target, the second threshold amount being greater than the first threshold amount.

2. The uninterruptible power system according to claim **1**, wherein the path switching unit performs switching of the path in such a manner that any of the rechargeable batteries is charged by any of the charging circuits or switching of the path in such a manner that power is supplied from any of the rechargeable batteries to any of the output circuits.

3. The uninterruptible power system according to claim **1**, wherein the control unit controls the path switching unit for the uninterruptible power unit that is a power appropriation target whose input current is larger than or equal to a threshold value, to switch to a path via which power from the rechargeable battery in the other uninterruptible power unit is supplied to the output circuit in the uninterruptible power unit that is the power appropriation target.

4. The uninterruptible power system according to claim **1**, wherein:

different priorities are set in the plurality of uninterruptible power units, and

the control unit controls the path switching unit to switch to a path via which power from the rechargeable battery of the uninterruptible power unit having a lower priority is supplied to the output circuit of one uninterruptible power unit when the power of the rechargeable battery is output from the uninterruptible power unit.

5. A method of controlling a power supply in an uninterruptible power system, the method comprising:

preparing a plurality of uninterruptible power units each including a rechargeable battery, a charging circuit configured to charge the rechargeable battery using input power, and an output circuit configured to output power stored in the rechargeable battery in place of the input power when supply of the input power stops, the uninterruptible power units being connected in parallel to the input power; and

controlling a path switching unit so that switching of a path for power received among the charging circuit, the rechargeable battery and the output circuit in the plurality of uninterruptible power units is performed according to states of the uninterruptible power units

wherein, in the controlling step, controlling the path switching unit to switch to a path via which rapid charging of the rechargeable battery that is a charging target, whose remaining amount is smaller than or equal to a first threshold amount, is performed by the charging circuit in the uninterruptible power unit including the rechargeable battery that is the charging target, as well as by the charging circuits of the uninterruptible power units other than the uninterruptible power unit including the rechargeable battery that is the charging target, and

wherein, in the controlling step, controlling the path switching unit to switch to a path via which slow charging of the rechargeable battery that is a charging target, whose remaining amount is greater than or equal to a second threshold amount, is performed by the charging circuit in the uninterruptible, power unit including the rechargeable battery that is the charging target, the second threshold amount being greater than the first threshold amount.

6. A non-transitory computer-readable recording medium having a program stored therein for causing a computer to execute a control step of controlling, according to states of a

plurality of uninterruptible power units each including a rechargeable battery, a charging circuit configured to charge the rechargeable battery using input power, and an output circuit configured to output power stored in the rechargeable battery in place of the input power when supply of the input power stops, a path switching unit so that switching of a path for power received among the charging circuit, the rechargeable battery and the output circuit in the plurality of uninterruptible power units is performed, the uninterruptible power units being connected in parallel to the input power,

wherein, in the control step, controlling the path switching unit to switch to a path via which rapid charging of the rechargeable battery that is a charging target, whose remaining amount is smaller than or equal to a first threshold amount, is performed by the charging circuit in the uninterruptible power unit including the rechargeable battery that is the charging target, as well as by the charging circuits of the uninterruptible power units other than the uninterruptible power unit including the rechargeable battery that is the charging target, and

wherein, in the control step, controlling the path switching unit to switch to a path via which slow charging of the rechargeable battery that is a charging target, whose remaining amount is greater than or equal to a second threshold amount, is performed by the charging circuit in the uninterruptible power unit including the rechargeable battery that is the charging target the second threshold amount being greater than the first threshold amount.

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